REMARKS

Claims 1-3, 5-7 and 9-25 are pending in the application. By this Amendment, Claims 1, 5, 10 and 22 have been amended to even more clearly recite and distinctly claim Applicants' invention, Claims 4 and 8 have been canceled, and Claim 25 has been added. Claim 1 has been amended to recite an oxygen-free single-fluorocarbon etching gas comprising at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas. Claim 5 has been amended to recite that the fluorocarbon reactant is selected from the group consisting of C_5F_8, C_4F_8, and C_4F_6. Claim 22 has been amended to recite an oxygen-free etching gas, support for which can be found in the specification at, for example, page 15, lines 4-5 and in Table 4. Support for new Claim 25 can be found in the specification at, for example, page 18, line 21. No new matter has been added. Reconsideration and allowance of the application are respectfully requested in light of the above amendments and the following remarks.

Rejection Under 35 U.S.C. § 112, ¶2

Claims 22-24 stand rejected under 35 U.S.C. § 112, ¶2.
Claim 22 has been amended to replace "the total C_4F_8 and CF_2H_2 flow rate is less than the N_2 flow rate and the flow rate ratio of the fluorocarbon reactant to the nitrogen reactant is 30% or less" with "the total C_4F_8 and CF_2H_2 flow rate is 30% or less of the N_2 flow rate."

Withdrawal of the rejection is respectfully requested.

Rejection Under 35 U.S.C. § 102

Claims 1, 4-9, 11, 14-16, and 19-21 stand rejected under 35 U.S.C. § 102(e) as allegedly being anticipated by U.S. Patent No. 6,693,042 ("Sedigh"). The reasons for the rejection are stated on page 3 of the Office Action. The rejection is respectfully traversed.

Sedigh is cited in the Office Action as disclosing: (1) a method that comprises the plasma etching of a low-k dielectric material such as fluorine-doped silicon oxide; (2) using an etchant comprising a hydrofluorocarbon, for example, $C_xH_yF_z$ with a flow rate of 2-8 sccm and nitrogen with a flow rate of 5-25 sccm; (3) patterning the dielectric etching by etching through an overlying hard masking material, such as undoped silicon oxide; (4) that the dielectric layer overlies a conductive layer, for example, aluminum; (5) that C_4F_8, C_4F_6, C_5F_8 may be added to the etchant; (6) etching patterns with features smaller than 0.2 microns; (7) that the method is part of a damascene process in which the etched feature is subsequently filled with metal; and (8) using an apparatus with high and low frequency RF power.

Sedigh discloses a method for etching a dielectric layer formed upon a barrier layer with a dielectric layer: barrier layer selectivity of at least approximately 20:1, but may range from approximately 20:1 to approximately 50:1. (Abstract) Sedigh further discloses that the barrier layer "may include a metal or a metal alloy. For example, appropriate materials for barrier layer 14 may include titanium, titanium nitride (TiN), titanium tungsten (TiW), tantalum (Ta), or tantalum nitride (TaN)." (Column 7, Lines 63-67) Sedigh additionally discloses a masking layer that may be formed on the dielectric layer and that may include a hard mask layer, a photoresist layer, or a combination of both. (Column 9, Lines 37-39)

Rather than disclosing $C_xH_yF_z$ with a flow rate of 2-8 sccm and nitrogen with a flow rate of 5-25 sccm, Sedigh discloses approximate flow rates of: (1) 2-8 sccm $C_2H_2F_4$ (Column 11, Lines 9-10); (2) 10-60 sccm CF_4 (Column 11, Lines 10-11); (3) 30-100 sccm CHF_3 (Column 11, Lines 11-12); and (4) 5-25 sccm nitrogen (Column 11, Lines 14-16). Accordingly, Sedigh discloses approximate flow rates of 42-168 sccm fluorocarbon reactant ($C_2H_2F_4$, CF_4, and CHF_3; see Claim 13) and 5-25 sccm nitrogen reactant. Thus, in Sedigh, the total fluorocarbon reactant flow rate is always greater than the nitrogen reactant flow rate.

Sedigh does not disclose the combination of features recited in Claim 1, which include: (1) an oxygen-free single-fluorocarbon etching gas comprising at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas, (2) a fluorocarbon reactant flow rate less than a nitrogen reactant flow rate, and (3) a etch rate selectivity of the etching rate of the low-k dielectric layer to the etching rate of the mask layer of at least about 5.

As explained in MPEP § 2131, "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

Applicants respectfully submit that Claim 1 is not anticipated by Sedigh, as each and every element as set forth in the claim is not found in Sedigh. Specifically, Sedigh does not disclose or suggest an oxygen-free single-fluorocarbon etching gas comprising at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas; a total

fluorocarbon reactant flow rate less than a nitrogen reactant flow rate; or a etch rate selectivity of the etching rate of the low-k dielectric layer to the etching rate of the mask layer of at least about 5. Rather, Sedigh discloses a combination of fluorocarbons ($C_2H_2F_4$, CF_4, and CHF_3), none of which are represented by C_nF_m wherein n is at least 4 and m is at least 6, whose flow rate is greater than the nitrogen reactant flow rate and a dielectric layer: barrier layer selectivity of at least approximately 20:1. The overlying mask layer of Claim 1 is significantly different than the barrier layer of Sedigh, upon which a dielectric layer is formed.

In accordance with the initial indication given by the Examiner in a telephone conversation with the undersigned on February 17, 2004, during which the above points were discussed, withdrawal of the rejection under 35 U.S.C. § 102(e) is respectfully requested.

Rejections Under 35 U.S.C. § 103

- I -

Claims 22 and 23 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 5,843,847 ("Pu"). The reasons for the rejection are stated on page 4 of the Office Action. The rejection is respectfully traversed.

Pu is cited in the Office Action as disclosing: (1) a method of plasma etching doped glasses such as PSG and BPSG; (2) an oxide to resist selectivity of at least 10:1; (3) an etchant composition comprising a fluorocarbon selected from a second group that includes C_4F_8, a fluorocarbon selected from a first group that includes CF_2H_2, and N_2; (3) a N_2:(C_4F_8+CF_2H_2) flow ratio of up to 5:1 and a CF_2H_2:C_4F_8 ratio of 1:1.

The Office Action acknowledges that Pu does not disclose the combination of C_4F_8 and CF_2H_2, but asserts that it would have been obvious to one skilled in the art to use the C_4F_8+CF_2H_2 combination because C_4F_8 is identified as the preferred fluorocarbon from the second group and CF_2H_2 is but one of five fluorocarbons which belong to the first group.

Pu discloses a process gas comprising (i) fluorocarbon gas for etching the dielectric layer and for forming passivating deposits on the substrate, (ii) carbon-oxygen gas for enhancing formation of the passivating deposits, and (iii) nitrogen-containing gas for etching the passivating deposits on the substrate. (Abstract)

Claim 22 has been amended to recite that the etching gas is "oxygen-free". Oxygen degradation of low-k films can be minimized by using an oxygen-free etch gas for etching organic low-k material. (Page 18, Lines 11-14) Further, oxygen-free etch gas avoids etching the silicon carbide layer. (Page 19, Lines 9-11)

As explained in MPEP § 2142, to establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

Applicants respectfully submit that Pu does not disclose or suggest all the claim limitations. Specifically, Pu does not disclose or suggest an oxygen-free etching gas. Rather, Pu discloses a process gas comprising a carbon-oxygen gas.

In accordance with the initial indication given by the Examiner in a telephone conversation with the undersigned on February 17, 2004, during which the above points were discussed, withdrawal of the rejection under 35 U.S.C. § 103(a) is respectfully requested.

- II -

Claim 24 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Pu in view of Koshiishi. The reasons for the rejection are stated on page 5 of the Office Action. The rejection is respectfully traversed.

The Office Action acknowledges that Pu does not disclose a dual frequency plasma system.

Koshiishi is cited in the Office Action as disclosing etching in a dual frequency plasma system wherein the pedestal electrode and the showerhead electrode are provided with different frequencies of RF energy.

The Office Action asserts that it would have been obvious to one skilled in the art to use the RF frequency scheme of Koshiishi because Koshiishi teaches that this enables greater control over the etching process.

Applicants respectfully submit that Pu in view of Koshiishi does not disclose or suggest all the claim limitations. Specifically, Pu does not disclose or suggest an oxygen-free etching gas. Rather, Pu discloses a process gas comprising a carbon-oxygen gas. Koshiishi, cited as disclosing etching in a dual frequency plasma system, does not cure the deficiencies of Pu in this regard.

In accordance with the initial indication given by the Examiner in a telephone conversation with the undersigned on February 17, 2004, during which the above

points were discussed, withdrawal of the rejection under 35 U.S.C. § 103(a) is respectfully requested.

- III -

Claims 1-24 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 6,455,411 ("Jiang") in view of Koshiishi. The reasons for the rejection are stated on pages 5-7 of the Office Action. The rejection is respectfully traversed.

Jiang is cited in the Office Action as disclosing: (1) plasma etching a low-k dielectric layer; (2) using an etchant comprising a fluorocarbon and a greater amount of nitrogen; (3) etching low-k dielectric layers through an overlying patterned layer of SiN, which functions as a mask for the subsequent etching of the underlying layer of low-k dielectric; (4) etching a layer of low-k dielectric that is disposed upon an underlying layer of SiC; (5) C_4F_8, C_4F_6, and CH_2F_2 as fluorocarbon etchants; (6) adding Ar to the etchant; (7) an etchant mixture consisting of C_4F_8, N_2, and Ar; (8) etching a layer of low-k dielectric material that overlies a barrier layer comprising TaN; (9) using a fluorocarbon flow rate that is less than 30% of the nitrogen flow rate; and (10) that the etched feature is filled with metal.

The Office Action acknowledges that Jiang does not disclose: (1) etching a feature with at least a 5:1 aspect ratio; (2) a dual frequency plasma system; (3) using an etchant that consists essentially of C_5F_8, N_2, and Ar, or (4) the temperature of the substrate support.

Koshiishi is cited as disclosing etching in a dual frequency plasma system wherein the pressure is up to 11 Pa and the pedestal and showerhead electrodes are provided with different frequencies of RF energy.

The Office Action asserts that it would have been obvious to one skilled in the art to use the RF frequency scheme of Koshiishi because Koshiishi teaches that this enables greater control over the etching process.

The Office Action asserts that it would have been obvious to one skilled in the art to appropriately adjust the process parameters such as the temperature of the substrate because optimization of such parameters is considered to be obvious.

Jiang discloses a dual damascene process for low-k or ultra low-k dielectric. (Abstract) Jiang discloses a via etch followed by trench etch. (Column 2, Lines 8-12) The via etch chemistry preferably comprises C_5F_8, N_2 and CO. (Column 3, Lines 24-26) The trench etch chemistry comprises a less-polymerizing fluorocarbon with a more-polymerizing fluorocarbon, nitrogen and argon. (Column 3, Lines 45-47) A less-polymerizing fluorocarbon refers to a C:F ratio of less than 1:3, examples of which include CF_4, C_2F_6, and C_XF_{3X+y} (Y>=0), and examples of more-polymerizing fluorocarbons include C_4F_8, C_5F_8, C_4F_6, $C_XH_YF_{2X+Z}$ (Z>=0, Y>=0). (Column 3, Lines 50-52) The combined fluorocarbons improve etch rate without increasing oxide ridges or increasing CD bias. (Column 4, Lines 8-9) Jiang further discloses that various C:F ratios can be achieved by adjusting the flow rate of the two fluorocarbons, which is not possible with a single fluorocarbon. (Column 4, Lines 18-21)

A prior art reference must be considered in its entirety, *i.e.*, as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984). Applicants respectfully submit that Jiang teaches away from an oxygen-free single-fluorocarbon etching gas, comprising at least one

nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas, for etching openings while providing a etch rate selectivity of the etching rate of a low-k dielectric layer to the etching rate of a mask layer of at least about 5. Rather, Jiang discloses a trench etch chemistry comprising a less-polymerizing fluorocarbon (C:F ratio of less than 1:3) with a more-polymerizing fluorocarbon and that various C:F ratios cannot be achieved with a single fluorocarbon.

Applicants respectfully submit that Jiang in view of Koshiishi does not disclose or suggest all the claim limitations. Specifically, Jiang in view of Koshiishi does not disclose or suggest an oxygen-free single-fluorocarbon etching gas, comprising at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas, for etching openings while providing a etch rate selectivity of the etching rate of a low-k dielectric layer to the etching rate of a mask layer of at least about 5. Koshiishi, cited as disclosing etching in a dual frequency plasma system, does not cure the deficiencies of Jiang in this regard.

With regard to Claim 17, the Office Action asserts that it would have been obvious to one skilled in the art that Jiang was applicable to etching of features with a 5:1 aspect ratio because Jiang teaches etching a contact hole to a depth of 10,500 angstroms and the industry standard for the size of contact holes at the time of Jiang's disclosure was 0.2 microns or less and in combination with an etching depth of 10,500 angstroms, this corresponds to a 5:1 aspect ratio.

As explained in MPEP § 2144.03, it is not appropriate for the Examiner to take official notice of facts without citing a prior art reference where the facts asserted to

be well known are not capable of instant and unquestionable demonstration as being well-known. *In re Ahlert*, 424 F.2d 1088, 1091, 165 USPQ 418, 420-21 (CCPA 1970). Accordingly, Applicants respectfully request that the Examiner provide a prior art reference disclosing that the industry standard for the size of contact holes at the time of Jiang's disclosure was 0.2 microns or less.

With regard to Claim 18, the Office Action asserts that it would have been obvious to one skilled in the art to use an etchant consisting of C_5F_8, N_2, and Ar because Jiang discloses an etchant consisting of C_4F_8, N_2, and Ar and that C_4F_8 and C_5F_8 are functional equivalents as the fluorocarbon component of the etchant mixture.

Applicants point out that Jiang does not disclose an etchant consisting of or consisting essentially of C_4F_8, N_2, and Ar. Rather, Jiang discloses a via etchant comprising C_5F_8, N_2 and CO and a trench etchant comprising a less-polymerizing fluorocarbon (*e.g.*, CF_4, NF_3, C_2F_6), a more-polymerizing fluorocarbon (*e.g.*, C_4F_8, C_5F_8, C_4F_6), N_2, and Ar. Thus, Jiang does not disclose or suggest an etching gas consisting essentially of C_5F_8, N_2 and Ar, as recited in Claim 18.

In accordance with the initial indication given by the Examiner in a telephone conversation with the undersigned on February 17, 2004, during which the above points were discussed, withdrawal of the rejection under 35 U.S.C. § 103(a) is respectfully requested.

Conclusion

Therefore, allowance of the application is respectfully requested. Should the Examiner desire to discuss this application, the undersigned attorney can be reached at the telephone number given below.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

Date: February 22, 2005

By: _____
Asaf Batelman
Registration No. 52,600

P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620